1.1.1

KITSAP COUNTY HEALTH DISTRICT

SCOTT W. LINDQUIST, MD, MPH, DIRECTOR
109 AUSTIN DRIVE
BREMERTON, WA 98312-1805
(360) 337-5235

February 24, 2003

Ching-Pi Wang, TCP/NWRO
Department of Ecology
3190 160th Ave. SE
Bellevue, WA 98008-5452

RE: BREMERTON AUTO WRECKING LANDFILL GROUNDWATER MAP

Dear Mr. Wang:

The Kitsap County Health District (Health District) is writing to comment and clarify the groundwater situation you discussed in your letter to the Health District dated February 14, 2003, regarding the Bremerton Auto Wrecking Landfill (BAWL).

Attached is a map developed in our office with data from the local water PUD and Kitsap County's GIS office. The orange triangle shape in the lower center of the map is BAWL. The travel bars that run diagonally from bottom to top have at their head the City of Bremerton production wells for approximately 10,000 persons. Given the topography and the heavy drawn down from the City of Bremerton production wells it is reasonable to assume that groundwater flow is to the north, not northeast as stated in the SHA.

If you have any questions please feel free to call. I can be reached at (360) 337-5607.

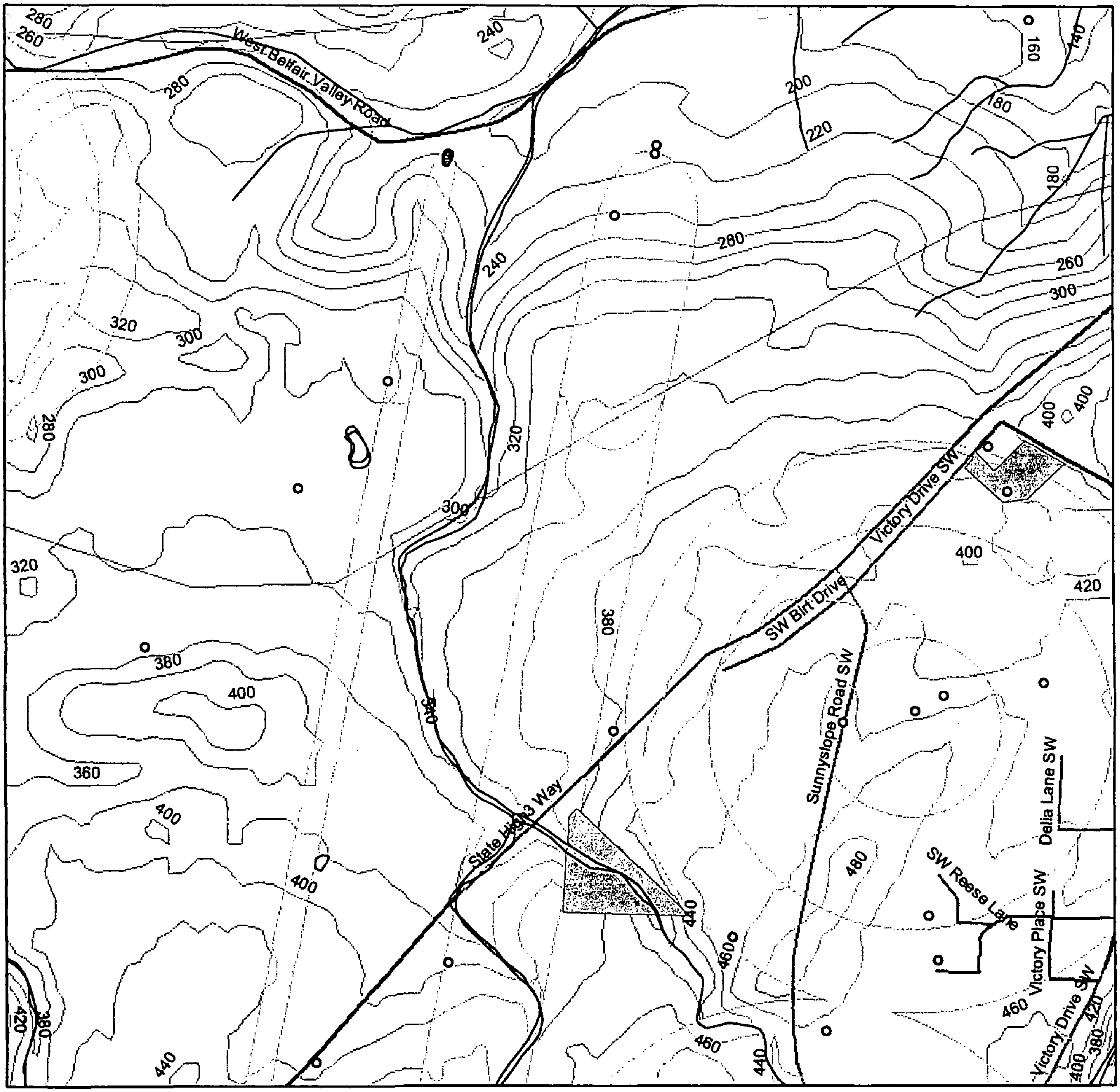
Sincerely,

Grant A. Holdcroft, R.S.
Environmental Health Specialist
Solid and Hazardous Waste Program

cc: Joanne LaBaw, USEPA
Steve Alexander,
Michael Spencer, Ecology

gah/swwqbdc/facility/BAWL/bawlgwflow

Bremerton Auto Wrecking Landfill



Legend

Groundwater travel time

1YR

5YR

10YR

aquifers

wellsDCD

0 500 1,000 2,000 3,000 4,000 Feet

N

2/24/2003

URS **Technical Memorandum**

To:	Larry Tucker Engineering Project Manager Engineering Field Activity – Northwest	From:	Mike Fitzmaurice Staff Engineer
		Date:	January 25, 2001

Project: Gorst Creek Landfill, Operations and Maintenance
Contract Number: N44255-98-D-4409 Delivery Order: 0020

Subject: Gorst Creek Hydrologic Modeling

This memorandum present the results of hydrologic modeling performed to estimate peak flows and runoff volumes from the Gorst Creek watershed upstream of State Highway 3 in Kitsap County, Washington.

Background

Gorst Creek is a small, ungauged tributary to Sinclair Inlet in Kitsap County, Washington. The Gorst Creek Landfill is located in a ravine just upstream of the State Highway 3 culvert crossing about 3 miles southwest of the town of Gorst (Figure 1). The drainage basin upstream of the highway crossing encompasses approximately 162 acres (0.25 square miles). For the purposes of this analysis, the basin upstream of the highway was divided into two sub-basins. Land use in the lower sub-basin consists of about 118 acres of mostly undeveloped, forested land, with the exception of an auto wrecking yard east of the stream channel that occupies about 16 acres (~ 9 %) of the basin. Land use in the upper sub-basin (east of SW Sunnyslope Road) consists of approximately 43 acres of low-density residential development.

The landfill essentially forms a small dam on Gorst Creek. Flow is conveyed underneath the landfill through a single 24-inch-diameter, corrugated metal culvert. It is currently thought that the culvert is either crushed or clogged with debris. Alternatives being considered to prevent upstream flooding or overtopping of the landfill include the construction of a bypass structure to re-divert Gorst Creek through or around the landfill.

Gorst Creek is an intermittent stream upstream of the highway crossing, and discharge data are presently not available. For this reason, standard hydrologic modeling techniques were used to provide a reasonable estimate of peak discharges and runoff volumes that could be used in the design of a bypass structure.

Modeling Methods

Because the Gorst Creek watershed is relatively small, the U.S. Army Corps of Engineer's HEC-1 model was used in lieu of a more complicated continuous simulation model. Hydrographs for the basin upstream of the highway crossing were generated for the 2-, 5-, 10-, 25-, 50-, and 100-year, 24-hour SCS type IA synthetic design storms. The storm "types" were developed by the SCS to describe the temporal distribution of rainfall over the duration of the storm. Four distributions were developed for four geographic regions within the United States. In Washington, the storm types 1A and II have been designated for western and eastern parts of the state, respectively.

Basin physical characteristics and land uses were determined from digital mapping obtained from Kitsap County. Basin soil types were obtained from the *Kitsap County Area Soil Survey* (SCS, 1981) and were used to determine the hydrologic groups of basin soils. In the HEC-1 model, the relationship between rainfall and runoff can be expressed as a curve number. An area-weighted curve number was developed to account for different runoff characteristics of the upper sub-basin, the auto wrecking yard, and the lower sub-basin.

The time parameter used in the HEC-1 model is the SCS lag time, which is proportional to the time of concentration by a factor of 0.6. The time of concentration is a measure of the time required for the entire watershed area to contribute to runoff. This was estimated using methods presented in the Washington State Department of Transportation *Highway Runoff Manual* (WSDOT, 1995). Rainfall depths were obtained from NOAA's precipitation frequency maps for Washington State (NOAA, 2000). The key hydrologic variables used in the model are presented below in Table 1. The complete input file is attached.

Table 1
KEY HYDROLOGIC VARIABLES FOR MODEL

BASIN CHARACTERISTICS	VALUE
Basin Area	0.25 sq. miles
Area-weighted Curve Number	75
Time of Concentration (Lag Time)	1.4 hour (0.82 hour)
Rainfall Distribution	SCS Type 1A, 24-hr duration

Modeling Assumptions

Assumptions made with respect to the Gorst Creek HEC-1 model include:

- No routing was performed from the upper sub-basin to the lower sub-basin through the existing 36-inch culvert. Reasonably accurate survey data immediately upstream of the culvert are necessary to define a stage-storage relationship.

- A future diversion structure will replace the existing landfill culvert, so the model did not include the existing 24-inch landfill culvert.

Modeling Results and Discussion

Results of the HEC-1 model runs are presented in Table 2 and hydrographs are plotted in Figure 2.

Table 2
SCS TYPE 1A DISTRIBUTION, 24-HOUR DURATION

Recurrence Interval	Rainfall Depth (in)	Peak Flow (cfs)	Total Runoff Volume (ac-ft)
2-yr	3.0	16	13
5-yr	3.7	28	20
10-yr	4.2	38	25
25-yr	5.0	55	33
50-yr	5.5	66	39
100-yr	6.0	77	45

Notes:
in = inches
cfs = cubic feet per second
ac-ft = acre-foot

The peak flows listed above are likely to be conservative (i.e., worst-case) estimates because in SCS methodology, the time of concentration is calculated assuming all runoff occurs via surface flow. The model thus shows much of the total runoff arriving at the basin outlet quickly, resulting in high peak flows. The actual time of concentration may be much longer as rainfall infiltrates into the soil and emerges later as interflow and seepage. Performing a separate model run routing flow from the upper to the lower sub-basin would also probably yield smaller numbers as a result of flow attenuation at the road culvert.

The estimates of runoff volumes are probably less conservative, as there is no dependency on time parameters. This information may be useful if detention of some proportion of the total runoff is desired.

Because the total basin area is small, relatively large errors in peak flow estimates are likely to be of little consequence in terms of the overall project cost of a diversion facility. (Pipe conveyance increases with the square of the diameter, and pipe costs will probably be small compared to other project costs). For this same reason, there is little practical value in attempting to validate the above results from a comparison to a similar, gauged basin.

References

NOAA web site. *Washington Precipitation Frequency Maps* (2000)

USDA Soil Conservation Service. *Kitsap County Area Soil Survey* (1981)

Washington State Department of Transportation. *Highway Runoff Manual* (1995)

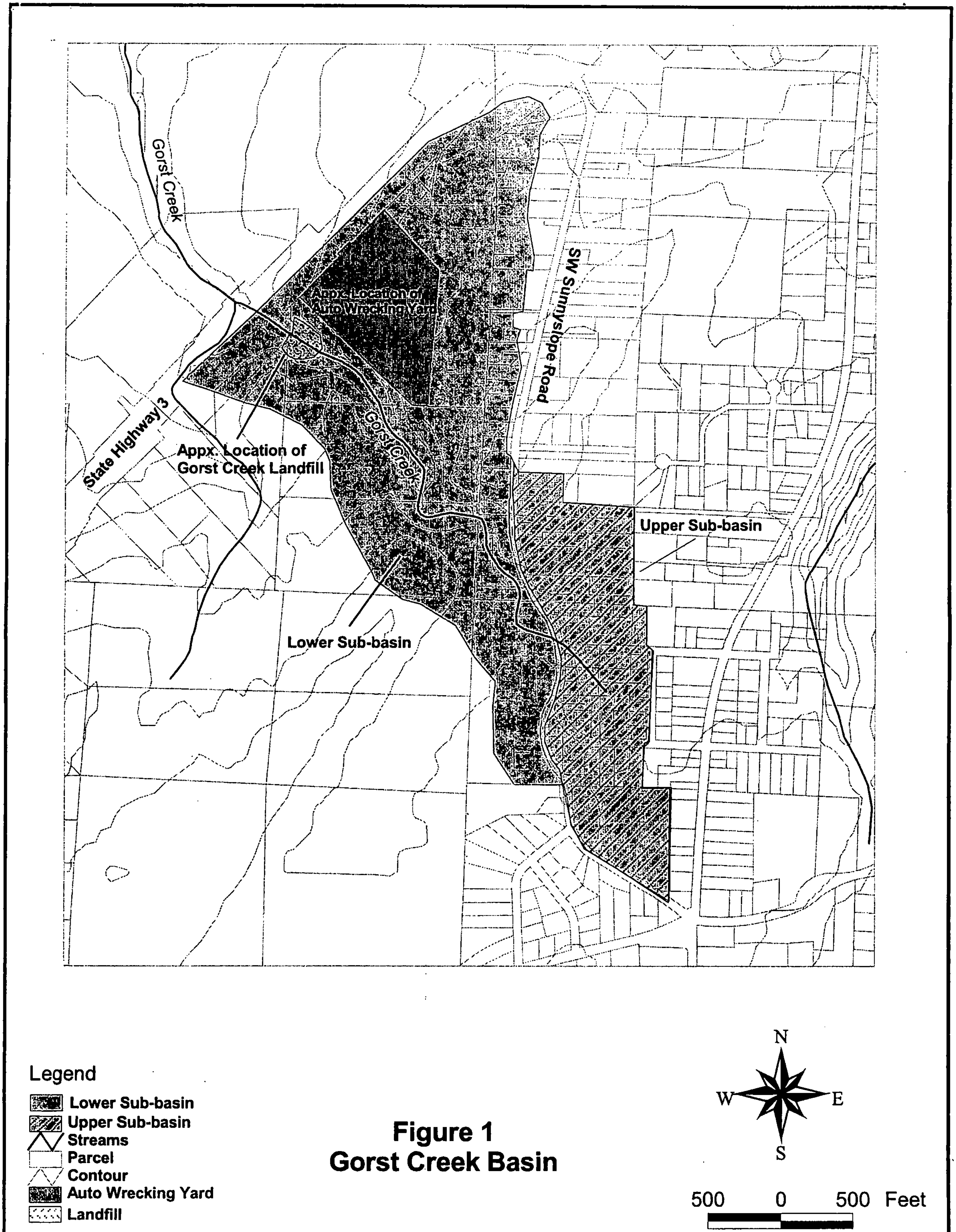


Figure 1
Gorst Creek Basin

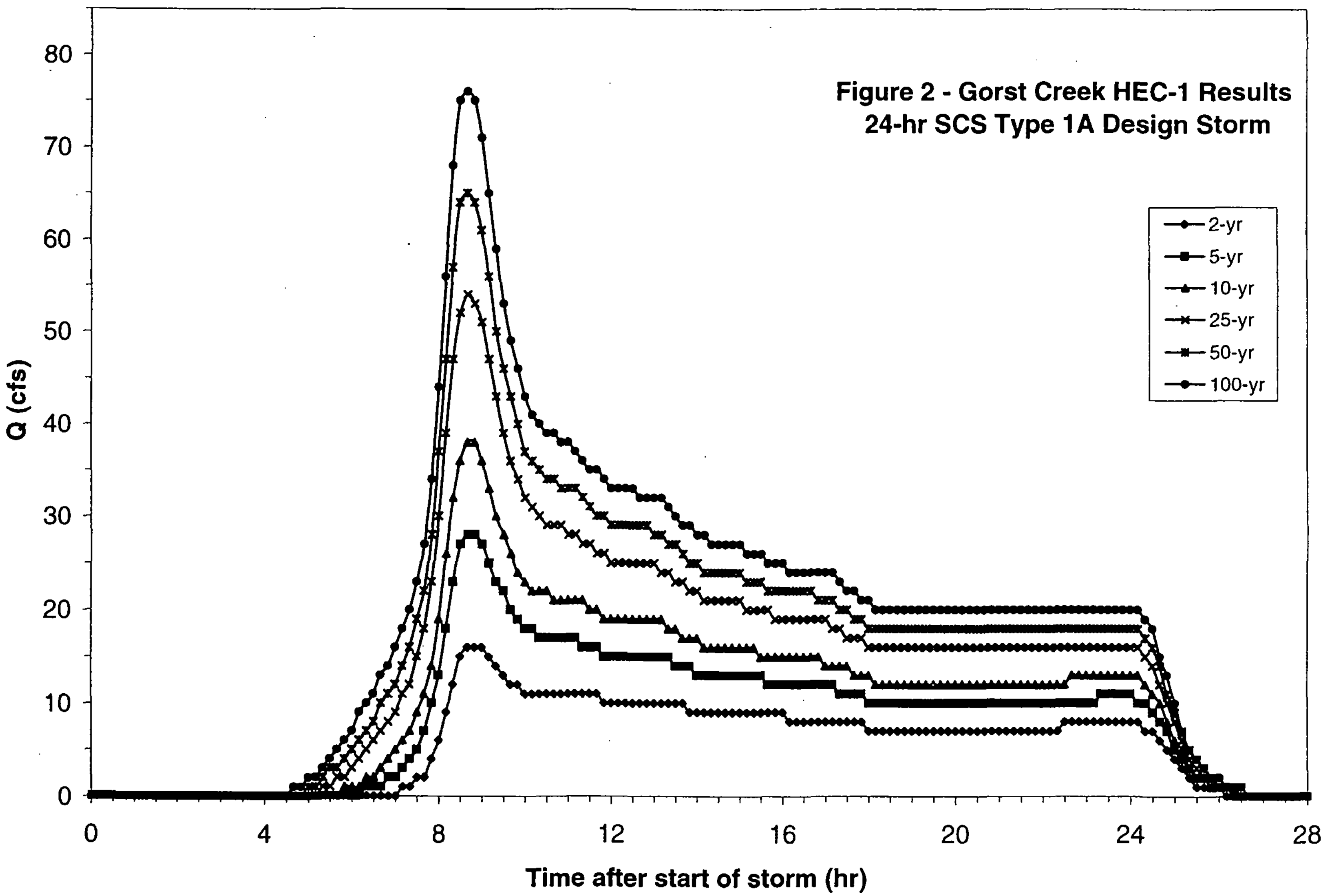


Figure 2 - Gorst Creek HEC-1 Results
24-hr SCS Type 1A Design Storm
2-yr
5-yr
10-yr
25-yr
50-yr
100-yr
Q (cfs)
0
10
20
30
40
50
60
70
80
0
4
8
12
16
20
24
28
Time after start of storm (hr)

HEC-1 Input File

```
ID       Kitsap County, Gorst Creek
ID       2, 5, 10, 25, 50, 100-YR, 24-HOUR TYPE IA STORM
ID       10-minute time step
IT    10 01JAN90    0000      300
IO     1
JR  PREC      3.0       3.7       4.2       5.0       5.5       6.0
*
KK Entire
KM   Runoff from Entire basin
BA  0.25
IN    10 01JAN90    0000
PB     0
PC 0.000    0.004     0.008     0.012     0.016     0.020     0.024     0.028     0.032     0.036
PC 0.040    0.045     0.050     0.055     0.060     0.065     0.070     0.076     0.082     0.088
PC 0.094    0.100     0.106     0.113     0.120     0.127     0.134     0.141     0.148     0.156
PC 0.164    0.173     0.181     0.189     0.197     0.207     0.216     0.226     0.235     0.245
PC 0.254    0.268     0.281     0.294     0.312     0.330     0.364     0.418     0.445     0.463
PC 0.477    0.490     0.504     0.512     0.521     0.530     0.539     0.548     0.556     0.565
PC 0.574    0.583     0.592     0.600     0.609     0.616     0.624     0.631     0.638     0.645
PC 0.652    0.660     0.667     0.674     0.681     0.688     0.696     0.701     0.707     0.713
PC 0.718    0.724     0.730     0.736     0.741     0.747     0.753     0.758     0.764     0.769
PC 0.774    0.779     0.784     0.789     0.794     0.799     0.804     0.809     0.814     0.819
PC 0.824    0.828     0.832     0.836     0.840     0.844     0.848     0.852     0.856     0.860
PC 0.864    0.868     0.872     0.876     0.880     0.884     0.888     0.892     0.896     0.900
PC 0.904    0.908     0.912     0.916     0.920     0.924     0.928     0.932     0.936     0.940
PC 0.944    0.948     0.952     0.956     0.960     0.964     0.968     0.972     0.976     0.980
PC 0.984    0.988     0.992     0.996     1.000
BF  0.00     0.00
LS           75.0
UD  0.82
*
ZZ
```

FOSTER WHEELER ENVIRONMENTAL CORPORATION

November 15, 1999
FWBEL-RACII-99-4778
2.4 Delivery Order File/Outgoing

Mr. Larry Tucker
Engineering Field Activity, Northwest
Naval Facilities Engineering Command
19917 7th Avenue NE
Poulsbo, Washington 98370-7570

RE: Review of conditions and interim action alternatives for Gorst Creek Landfill, Kitsap County, Washington, Delivery Order 50, Task 38.

Ref: Contract N44255-95-D-6030 (RAC II), Environmental Remedial Action Contract For Sites in Washington, Oregon, Idaho, Montana, and Alaska

Dear Mr. Tucker:

The following presents a review of the Gorst Creek Landfill conducted over the past several weeks by Foster Wheeler Environmental. The review has been undertaken in response to the Technical Direction Letter dated September 29, 1999 (Bill Clarno, EFA NW to Henry Morris, Foster Wheeler Environmental). Slope instabilities resulted in slides and erosion of the downstream slope of the landfill, which were observed following the winter of 1996/1997. Reconnaissance-level evaluations of the site were conducted at that time. This letter report takes a fresh look at site physical site conditions using previous reports and site visits to identify and prioritize alternatives for interim actions that address slope instabilities.

LANDFILL DESCRIPTION

The Gorst Creek Landfill is located along the southeast side of State Highway 3 approximately 2 miles south of Gorst and 1 mile north of the Bremerton Airport. It has been previously called the Ames Landfill and the Bremerton Auto Wrecking Landfill. The Gorst Creek Landfill is located on private property totaling about 9 acres. The Washington State Department of Transportation (WSDOT) owns the right-of-way that borders the landfill to the northwest, while Airport Auto Wrecking occupies adjacent land to the northeast. Private residential property borders the site to the east and south.

The unlined landfill was created in the late 1960's by filling in the small, V-shaped valley created by Gorst Creek. The valley is 300 to 400 feet wide at the top. A culvert pipe approximately 750 feet long was lain in the creek channel prior to valley filling in order to divert flow beneath the landfill. The top surface of the landfill is relatively flat, while the upstream and downstream slopes in the Gorst Creek drainage are steep at roughly 30 to 40 degrees from horizontal (Hart Crowser, 1999a). These upstream and downstream slopes are 50 to 60 feet high. The landfill received primarily construction debris, although miscellaneous other refuse was exposed on the downstream slope in 1997

(Foster Wheeler Environmental, 1997). The landfill's downstream slope and diversion discharge point are about 200 feet south of a culvert beneath State Highway 3.

In early 1997, WSDOT observed abundant garbage debris in Gorst Creek upstream of the culvert underneath State Highway 3. The debris was traced to the nearby downstream slope of the landfill, which evidently had experienced recent landsliding and rapid erosion. Recent discussion during a project meeting on October 6, 1999 with Rick Uhinck, son of property owner, and Steve Kalinowski, Department of Fish & Wildlife, indicates that a flood event in early 1997 resulted in a backup of water behind the upstream diversion entrance that overtopped the landfill. The creek then ran over the landfill surface and cascaded down the downstream landfill slope. This event clearly resulted in rapid erosion and may have been coupled with landsliding observed on the steep slope.

PREVIOUS EVALUATIONS AND ACTIONS

Evaluations of site conditions were conducted in 1997 for WSDOT by Hong West (1997) and for the Navy by Foster Wheeler Environmental (1997). The evaluations confirmed WSDOT concerns that debris from the landfill might plug the culvert beneath the highway, which could in turn threaten the highway stability if water ponded behind the embankment. WSDOT installed two rock walls in the creek bottom below the slide area to contain future debris released from mass wasting and erosion. More recently, a reconnaissance visit to review slope stability conditions noted continued concerns regarding the oversteepened nature of the slope on the landfill's downstream face (Hart Crowser, 1999b). The Navy currently is undertaking a site investigation to evaluate chemical conditions in soil, sediment, surface water, and groundwater at the landfill (Hart Crowser, 1999c).

EXISTING CONDITIONS

The downstream terminus of the diversion culvert for Gorst Creek beneath the landfill was buried by landslides in 1997 (Foster Wheeler Environmental, 1997; Hong West, 1997). Hong West reported that in April of 1997 they observed several seeps of water flowing from the base of the slope. They concluded that it was possible that the culvert was partially or completely blocked, so that the Gorst Creek water flowed under or through the landfill. Erosional gullies that expose landfill material also are evident at the top of the downstream slope. The topographic map (Hart Crowser, 1999a) shows that a large portion of the landfill surface drains to the downstream slope.

The upstream end of the diversion culvert was observed during a site visit on October 26, 1999 by Foster Wheeler Environmental. An inverted "T" is installed at the end of the culvert. The horizontal end of the "T" was buried under soil, wood branches, and underbrush. The soil and branches were removed with a hand shovel to expose a pie-shaped steel cage at the end of the pipe. The steel bars are spaced about 3 to 5 inches apart. The diversion pipe is a 24-inch-diameter corrugated metal pipe (CMP). The vertical end of the "T" is covered with another steel cage made from reinforcing steel. Steve Kalinowski, Department of Fish & Wildlife said on October 6, 1999 that he visited the entrance to the diversion culvert after flooding in early 1997 and discovered significant blockage that he then cleared. It is uncertain whether any maintenance to clear these screens had been done between visits in winter 1997 by Steve Kalinowski and in fall

1999 by Foster Wheeler Environmental, although Rick Uhinck stated on October 6, 1999 that he does not conduct maintenance.

The structural integrity of the diversion pipe is unknown. If the pipe is damaged, it may not be possible to clean the entire length. A vertical access to the diversion exists about 200 feet from the upstream culvert entrance but, apparently, no maintenance has been conducted via this access. In order for the diversion culvert to function effectively, it must flow freely into the Gorst Creek channel downstream of the landfill. Clearly, blockage has existed following the 1996-97 slide that buried the downstream end.

Rock barriers installed by WSDOT were designed to retain mass wasting debris. The upper rock wall (immediately below the downstream slope) has an 18-inch diameter CMP that lies beneath sand on the upstream side. Therefore, it is impossible to determine by inspection whether this is connected to the buried terminus of the diversion culvert. Subsequent to our visit, WSDOT has indicated that the culvert in the upper rock wall does not connect to the diversion culvert (Payton, 1999). Thus, the diversion culvert terminus remains buried beneath the slide material.

Both Hong West (1997) and Hart Crowser (1999a) state that control of surface and subsurface drainage is an important element in stabilizing the slope, and this review concurs. Extension of the diversion culvert was one of the recommendations by Foster Wheeler Environmental (1997). For stability of the landfill, it is essential that Gorst Creek water be prevented from flowing through or over the landfill. It is highly recommended that the flow be directed through the landfill within a free-flowing diversion pipe.

INTERIM ACTION ALTERNATIVES

Any temporary action to address immediate problems should be conducted as an interim action under the Model Toxics Control Act (MTCA; WAC 173-340-430). Since Ecology has not initiated any enforcement action, the interim action may be conducted as an independent remedial action. However, the independent action may not foreclose reasonable alternatives for future remedial actions.

This section describes and assesses interim action alternatives for the Gorst Creek Landfill. Interim actions are evaluated and prioritized in this letter regarding their ability to meet the following criteria:

- Mitigate landfill mass wasting (slides, slumps, etc).
- Lessen effect of surface water on landfill erosion.
- Protect sensitive habitat of Gorst Creek.
- Minimize cost.
- Complement or not foreclose future remedial alternatives.
- Minimize disruption of traffic on State Highway 3.

Several alternatives originating from previous recommendations and the current task team have been identified for consideration to address slope stability concerns. These alternatives will address immediate concerns, but may not provide long-term solutions. It is anticipated that some alternatives will be complementary such that the best mitigation would be achieved when applied conjunctively. Interim action alternatives considered for evaluation are listed below:

1. **Improve Diversion Flow** - Inspect and clean existing Gorst Creek diversion culvert under the landfill and recover the buried end of the diversion culvert to improve flow through the diversion and reduce water seepage through the slope face.
2. **Drain Landfill Slope** - Install horizontal drains in the slide area to reduce water seepage through the slope face.
3. **Surface Water Interception** - Intercept surface stormwater flow on the landfill surface and pipe around landslide area to reduce surface erosion on the downstream slope.
4. **Alter Slope Top** - Reduce slope angle to 3:1 (H:V) for the top 10 feet of slide scarp to reduce slide potential.
5. **Alter Entire Slope** - Reduce slope angle to 3:1 (H:V) for the entire landfill downstream face to reduce slide potential and stabilize the slope.
6. **Fill Placement** - Place fill material below the existing downstream face to create a slope angle of 3:1 (H:V). This would reduce slide potential and stabilize the slope.
7. **Engineered Wall** - Construct engineered wall at base of landfill downstream face to stabilize the slope.

An alternative that would address the landfill as a whole is installation of a landfill cap in accordance with the Washington Administrative Code (WAC) 173-304 "Minimum Functional Standards for Solid Waste Handling." Foster Wheeler Environmental (1997) estimated such a cap to cost $4 million to $5 million. Consideration of such a final measure is better reserved as a remedial action alternative. However, because the potential exists for future construction of a landfill cap, any alternative selected as an interim action should take into consideration its compatibility this possible remedial action.

Alternative 1 – Improve Diversion Flow

The intent of this alternative is to restore flow through the diversion culvert that underlies the landfill. It is possible that the existing diversion culvert was damaged beyond repair when buried by the landslide. If this is the case, a temporary shoring system would have to be designed to allow safe connection to the damaged pipe and permanent options would be evaluated during subsequent remedial design.

This alternative will begin with cleaning the pipe (if possible) and evaluating its structural integrity. Starting from the upstream end of the diversion, sediment and debris accumulated in the pipe will be removed using commercial storm sewer cleaning equipment. A remote video camera will be used to inspect the pipe and evaluate its integrity. Once the diversion culvert has been cleaned and inspected, the next phase of this alternative will be to extend the downstream terminus of the diversion beyond the current toe of the slope. Locating the terminus (currently obscured by landslide debris) will accomplished by using geophysical methods and/or excavation. Exposing the culvert end will be difficult because it requires excavation in soft soil at the base of the landslide area. One safe method would be to excavate a relatively narrow utility-type trench perpendicular to the creek channel. The sides of the excavation could be supported with a steel "trench-box." With this system of temporary shoring, excavations can be made to depths of 15 to 20 feet below the ground surface.

If the diversion pipe is damaged, it may not be possible to clean the entire length. Even so, it is hoped that reestablishing the downstream terminus and removing some blockage would encourage a greater proportion of the water to exit via the pipe rather than the slope face. Reestablishing greater flow also would diminish the threat of Gorst Creek backing up and overtopping the landfill in a flood event.

The approximate cost for reestablishing the downstream culvert is $70,000, including access road construction. The approximate cost to clean and evaluate the integrity of the diversion culvert is $50,000. Total cost for the alternative, thereby, is $120,000.

Alternative 2 – Drain Landfill Slope

This alternative would improve drainage in the unstable slope areas by installing horizontal drains from the face of the slope back into the soil. Horizontal drains function somewhat like horizontal wells and are a proven technology to dewater unstable slopes. A well screen is installed at the upslope end of the drain and is connected to a pipe that discharges the ground water into a collection system at the toe of the slope. For this site, drilling equipment would be placed at the toe of the slide and several horizontal borings drilled back into the landfill.

If the drains were installed as part of an interim action, the final grade on the slope would not be known unless Alternative 5 (below) is selected. The potential exists that the drains would be incorrectly positioned for long-term use and would have to be replaced as part of a remedial action. Additionally, the collection system would be vulnerable to slides from the oversteepened slopes if the current face is unaltered. For these reasons, horizontal drains may serve better when combined with other interim actions or as a component to a permanent remedy.

The estimated cost for installing horizontal drains is $100,000, including access road construction.

Alternative 3 – Surface Water Interception

The intent of this alternative is to establish control of the surface water flow that originates on the landfill surface and cascades down the downstream slope. In this alternative, a low berm and/or shallow interception ditch would be installed at the top of the slope along the downstream end of the landfill. The ditch would slope from a high point in the center of the landfill down towards both sides of the slope above the creek. Surface water would flow by gravity to the two sides of the landfill slope, where it would be collected into solid pipes. The pipes would be buried shallowly down the side slopes and would terminate in the Gorst Creek channel. A second method to deliver a greater volume of water from the landfill surface to the creek channel would be to create a vertical channel on the slope face that would be heavily lined with rip rap for armoring. The second option would be possible if Alternatives 4 or 5 are selected.

Surface water diversion would reduce surface erosion on the downslope face of the landfill. It would also provide slight reduction in the infiltration of surface water into the landfill and, thereby, provide concordant reduction in water seepage from the face of the landfill. It is likely that surface water interception would be replaced for the final design.

The approximate cost to divert surface water to the base of the slope using pipes is $100,000, including access road construction, and $130,000 if an open channel is used. Implementation of Alternatives 5 or 6 would likely complete much of this alternative, thereby eliminating most of the cost, while partial completion would be accomplished by Alternative 4.

Alternative 4 – Alter Slope Top

The goal of this alternative is to reduce the angle of the most precarious oversteepened slopes. The slope angle on the downslope end of the landfill is not uniform. The upper portion of the existing slope is nearly vertical over a height of about 10 feet across most of the landfill scarp. This is not stable, and there is a relatively high probability of additional sliding in the near future.

In this alternative, an excavator would work from the top of the slope to draw back the landfill material and reduce the slope to a the slope to 3:1 (H:V). The top-of-slope length is approximately 300 feet and would be pulled back approximately 30 feet, generating roughly 1,000 to1,500 cubic yards. The excavated landfill debris would be placed on the surface of the landfill and covered with clean soil. The new slope surface would be covered by 1 foot of clean soil (approximately 750 yards) that is stabilized by placing erosion matting and seeding with vigorous vegetation. It is likely that the new slope would be modified again in a remedial action.

Excavating into any landfill poses several concerns, including personnel and public exposure, release of new contaminants, and discovery of debris that may not be allowed to go back into the landfill (e.g., asbestos-containing material, PCBs, hazardous waste, state dangerous waste).

The approximate cost for Alternative 4 is $125,000.

Alternative 5 – Alter Entire Slope

This alternative seeks to permanently stabilize the downstream slope by cutting back the entire face to a 3:1 (H:V) slope. This would require excavating into the existing landfill, placing the debris onto the level portion of the landfill, and providing soil cover and erosion control measures for the newly created slope and the stockpiled debris. Using the assumption of an existing 3:2 (H:V) slope, approximately 15,000 cubic yards of material would need to be excavated and relocated. This modification would pull back the top of slope approximately 75 feet along its length. Approximately 2,000 cubic yards of imported soil cover would then be placed over the newly created slope and landfill surface. Erosion protection would be provided as described in Alternative 4.

This alternative includes the same concerns identified in Alternative 4 regarding excavating landfill material. This alternative has the advantage of providing long-term slope stability that is consistent with landfill cap slope requirements (WAC 173-304). Modification of the slope in a remedial action is unlikely.

The approximate cost for Alternative 5 is $500,000.

Alternative 6 – Fill Placement

This method of slope stabilization uses imported fill material to extend the existing slope downstream to create a more gentle slope angle. Creation of a slope would extend the base to near the lower 1997 rock wall installed by WSDOT. Some landfill material would likely be disturbed to reduce the vertical top face to allow earthmoving equipment close to the edge, which calls into play concerns identified in Alternative 4. The downstream terminus of the diversion culvert would be recovered and extended beyond the reach of the new fill. The new slope would extend well into the WSDOT right-of-way. The surface of the new fill would be completed in the same form as Alternatives 4 and 5. Cost to extend the existing slope out to a stable slope and to extend the culvert is approximately $1,250,000.

Alternative 7 – Engineered Wall

An engineered wall made of rock, timbers, ecology blocks, concrete, or other means and combinations could be placed at the base of the landfill slope to retain further mass wasting. These types of walls are commonly used at the base of slide areas along highways, particularly over mountain passes, to prevent slides from running out onto the road. The landfill would continue to slide in this area,, until an equilibrium state is reached. The approximate size of the wall would be 150 feet long by 30 feet tall by 15 feet thick (being wider at the base). It is uncertain whether a wall would provide a significant benefit to a remedial action, but it could be worked into future actions. The cost of installing such a wall would be approximately $450,000, including access road construction.

ALTERNATIVE EVALUATIONS

The following discussion addresses feasibility issues and effectiveness of the alternatives, beginning with general feasibility issues. Table 1 lists each alternative and its ability to meet the evaluation criteria identified above.

Construction Access to Gorst Creek

Some alternatives require access to the base of the landfills downstream slope within the Gorst Creek drainage. Construction of a road to the base of the landfill's downstream slope would greatly improve access but is assumed to cost roughly $40,000 due to steep terrain. The road will require access approval from property owners. Road costs are factored into estimates for Alternatives 1 (Flow Diversion), 2 (Drain Slope), 3 (Surface Water Interception), and 7 (Engineered Wall).

Relocation of Landfill Debris

Alternatives 4 (Alter Slope Top), 5 (Alter Entire Slope), 6 (Fill Placement), and possibly 3 (Surface Water Interception) require excavation of landfill debris and relocation to the level landfill surface. The replacement of landfill debris within the landfill is expressly allowed under Washington Dangerous Waste Regulations (WAC 173-303-140; adopting the federal Land Disposal Restrictions, LDRs; 40 CFR 268)(*See* 51 FR 40577, November 7, 1986 and 54 FR 41566-67, October 10, 1989).

Mitigate landfill mass wasting

All of the alternatives identified will mitigate mass wasting. Those alternatives that modify the oversteepened slopes or provide the greatest dewatering will be the most effective. Combining alternatives such as 1 (Flow Diversion), 3 (Surface Water Interception), and 4 (Alter Slope Top) would provide the greatest interim protection for relatively low cost.

Lessen Effect of Surface Water on Landfill Erosion

Alternatives 3 to 7 will mitigate erosion, while Alternatives 1 (Flow Diversion) and 2 (Drain Slope) focus solely on slope stability. Those alternatives that control the surface water will provide the greatest protection, followed by alternatives that reduce the slope angles or provide a protective cover. By these measures, combining alternatives such as 1 (Flow Diversion), 3 (Surface Water Interception), and 5 (Alter Entire Slope) would provide the greatest interim protection.

Protect Sensitive Habitat of Gorst Creek

Alternatives that provide the best mitigation to landfill erosion and mass wasting will be the most protective of sensitive habitat in Gorst Creek.

Minimize Cost

The range in estimated costs for the alternatives is large. Low cost will be a significant factor in alternative selection, especially if alternatives are combined.

Complement or Not Foreclose Future Remedial Alternatives

Alternatives that provide good flow through the Gorst Creek diversion and reduce slopes to 3:1 (H:V) will best complement future remedial actions. Horizontal drains installed in Alternative 2 may not be fully compatible with some alternatives for final remedial design. Surface drainage control (Alternative 3) is unlikely to be retained in a remedial action unless it is combined with a downstream slope modification (Alternatives 5 or 6). The engineered wall of Alternative 7 may be compatible with a remedial design, but it may not relieve a remedial action from reducing slope to 3:1 (H:V).

Minimize Disruption of Traffic on State Highway 3

None of the alternatives is expected to significantly disrupt traffic on State Highway 3, with the exception of short-term lane closures to allow access into the Gorst Creek drainage.

PRIORTIZATION OF INTERIM ACTIONS

The priority for implementing the interim actions described in this report are evaluated for criteria listed above and shown in Table 1. The alternatives are divided into recommended alternatives and alternatives deferred for later consideration.

Recommended Alternatives

1. Alternative 1 – Improve Diversion Flow. Restoring flow to the Gorst Creek diversion is viewed as the most important interim action, making this alternative the highest rated.

2. Alternative 3 – Surface Water Interception. Controlling surface water flow would greatly reduce erosion potential and provide some slope stability by redirecting water. It rates equally important as Alternative 1.

3. Alternative 4 – Alter Slope Top. Pulling back the top of the slope would afford some increased slope stability. It offers much less protection than Alternative 5 against both mass wasting and erosion, but at about one quarter the cost. The modified slope would not be retained in a remedial action, although the same materials would likely require repositioning if a landfill cap were constructed.

4. Alternative 5 – Alter Entire Slope. This alternative affords the greatest mitigation to mass wasting and erosion, plus fully complements remedial actions. Higher cost is the main detraction, which results in a lower ranking for an interim action. If applied in combination, this alternative would eliminate some costs of other alternatives where activities overlap.

Table 1. Alternative evaluation.

	Alternatives						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Criteria	**Flow Diversion**	**Drain Slope**	**Surface Water**	**Alter Slope Top**	**Alter Entire Slope**	**Fill Placement**	**Engineered Wall**
Mitigate Mass Wasting	Good	Good	Good	Good	Excellent	Excellent	Good
Lessen Erosion	Poor (no change)	Poor (no change)	Excellent	Good	Excellent	Excellent	Excellent
Protect Habitat	Good	Good	Good	Good	Excellent	Excellent	Good
Minimize Cost	Good $120,000	Good $100,000	Good $130,000	Good $125,000	Fair $500,000	Poor $1,250,000	Fair $450,000
Complement Remedial Action	Excellent	Fair, not foreclosing future action	Fair, not foreclosing future action	Good	Excellent	Excellent	Fair, not foreclosing future action
Minimize Traffic Disruption	Good	Good	Good	Good	Good	Good	Good
Overall Rating 1/	Good	Fair	Good	Good	Excellent (but costly)	Good (but costly)	Fair

1/ Scoring was assigned as follows: 1-Poor, 2-Fair, 3-Good, 4-Excellent; then averaged for an overall rating.

Combining these alternatives would provide the greatest protection, while efficiencies and eliminating duplicate efforts for the components would result in lower total cost estimates. For example, combining Alternatives 1 (Flow Diversion), 3 (Surface Water Interception), and 4 (Alter Slope Top) would provide very good mitigation, while one of the assumed road construction costs would be eliminated and slope modification would complete some of the surface water control planned for Alternative 3 (say $300,000 total cost instead of $375,000). Combining Alternatives 1 (Flow Diversion), 3 (Surface Water Interception), and 5 (Alter Entire Slope) would provide the best mitigation at a higher cost, but access costs could be eliminated from Alternatives 1 and 3 and the remaining surface water control measures of Alternative 3 would be mostly included in Alternative 5 (say $600,000 total cost instead of $750,000).

Alternatives Deferred for Feasibility Study Analysis

The following alternatives have features that may be beneficial as part of the final remedial design and construction. However, due to relatively high cost and/or potential incompatibility with final design, they are not recommended for interim actions.

1. Alternative 2 – Drain Landfill Slope. Horizontal drains would be somewhat effective at improving slope stability. However, it is slightly questionable how well they would complement a remedial action. The need for horizontal drains would increase greatly if the downstream terminus of the creek diversion cannot be reestablished.
2. Alternative 6 – Fill Placement. Extending the slope would be effective for stabilization. However, it is expensive relative to Alternative 5 and would extend beyond the landfill property, thereby requiring property agreements.
3. Alternative 7 – Engineered Wall. The wall would be similar in cost to Alternative 5 but would not complement a remedial action in the same fashion because slope modification may still be required.

CLOSURE

I look forward to discussing the findings of our review presented in this letter report. Please call me with any questions at (206) 842-4249.

Sincerely,

Thomas C. Goodlin
Task Order Manager
FWENC – Navy RAC II

cc w/ enclosure:
B. Clarno

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